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Adoption of Technology-Enhanced Learning on Teaching Effectiveness in North-West Public Secondary Schools in Nigeria

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Abstract: ***The study aimed at investigating the adoption of Technology-Enhanced Learning (TEL) and its impact on teaching performance in public secondary schools of the North-West region of Nigeria. The study's five research objectives were to identify: the level of the teachers' involvement in TEL adoption; the impact of TEL on teaching effectiveness; types of TEL tools and resources used; challenges of the TEL adoption; and suggestions for enhancing the implementation of TEL in schools. The design of the study used was descriptive survey research design. The target population of the study was 60,410 teachers from public secondary schools in seven states of the North-West geopolitical zone. Proportionate stratified random sampling was used to obtain a sample of 630 teachers using the Yamane's formula (1967). The major instrument used for collecting data was a validated structured questionnaire which was found to have a reliability coefficient of Cronbach's Alpha 0.84. Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to analyse data. The research findings confirmed there is moderate level of TEL use by teachers, as digital communication tools like WhatsApp and email are the most common used tools for teachers to communicate instruction, while the institutional ICT infrastructure is inadequate. The results also demonstrated that the overall mean scores of TEL were all above the decision benchmark, meaning that TEL influences positively the teaching effectiveness, such as student engagement, lesson delivery, lesson planning, assessment practices, and classroom interaction. The study also found that mobile phones and WhatsApp are the most frequently used TEL tools, and other tools like projectors, online learning platforms, and digital libraries are moderately used. There are also many issues that hinder the adoption of TEL, such as no electricity, no internet connection, no ICT infrastructures, no teacher training and lack of policy support. The study's recommendations for strengthening effective technology integration in secondary schools include improving the power supply, provision of ICT devices, regular teacher training, upgrading internet connectivity, and designing an integrated TEL policy.***

Keywords: Technology-Enhanced Learning; Teaching Effectiveness; Public Secondary Schools; ICT Integration.

INTRODUCTION

With the emergence and development of digital technologies in all areas of human activity, the landscape of 21st century education has been changed entirely. The intentional use of digital tools, resources and platforms to enhance, enrich and transform teaching and learning processes, as a broad term for Technology-Enhanced Learning (TEL), is one of the most

impactful paradigm shifts in current educational practice (Ally & Samaka, 2023). TEL can be considered a spectrum of digital interventions ranging from the inclusion of interactive multimedia tools in science teaching to the use of adaptive learning platforms with artificial intelligence that can shift the way learning is experienced, content is structured and learning outcomes are assessed.

The need for technology to be integrated into education has been clearly set out in the policies and development agendas of most countries around the world. The enhancement of educational technologies is a key enabler for increasing access and improving learning outcomes, as stated in the explicit reference to the SDG 4, inclusive and equitable quality education (UNESCO, 2023). Indeed, advanced countries like South Korea, Finland, Singapore, and the United States have made significant investments in their educational technology infrastructure, teacher professional development, and the creation of digital curriculum resources, and have seen noticeable gains in student achievement and teacher efficacy throughout the educational system across different subjects (Adebayo & Oluwaseun, 2024).

However, the integration of TEL in formal education in sub-Saharan Africa is still limited by a variety of structural, institutional and capacity barriers. The widespread availability of mobile telecommunications within the continent brings new opportunities for mobile learning, but the adoption of such technologies to the classroom level remains slow and uneven (Hassan & Bala, 2022). Despite these gains, the uptake and impact of TEL in many African countries, including Nigeria, remains constrained by problems with electricity supply, the lack of adequate ICT support in schools, the lack of training for teachers on digital pedagogy and low policy implementation.

Nigeria, being the most populous country in Africa, also has one of the largest secondary school systems in Africa, with millions of secondary school students enrolled in 36 states and the Federal Capital Territory (FCT) and a secondary school system comprising tens of thousands of schools. The application of technology in public secondary school classrooms does not map out the intentions of the Nigerian Government in the National Policy on Education and the National Digital Economy Policy, with application being limited and uneven (Federal Ministry of Education, 2023). The policy aspirational and implementation gap is especially wide in the North-West geopolitical zone (Kaduna, Kano, Katsina, Jigawa, Kebbi, Sokoto and Zamfara) where educational outcomes have historically not improved beyond the national average, and where access to quality ICT infrastructure remains very limited (Abdullahi & Musa, 2023).

The North-West part of Nigeria is a unique and complex educational environment. The region faces some of the country's highest rates of children out of school, significant gender gap in school enrolment, a high level of poverty, episodic insecurity, as well as some of the most profound gaps in educational infrastructure in the country (UNICEF 2022). In public secondary schools (PSs) in this zone, teachers are the main agents of implementation of the curriculum and are the most direct influencers of the quality of learning in classrooms where they often work in resource constrained settings, with lack of professional support, and with limited access to digital tools and connectivity to facilitate effective TEL use.

However, there is a remarkable dearth of empirical research that specifically addresses the North-West geopolitical zone in this regard even though knowledge of the adoption of TEL and its impact on the effectiveness of teaching is of crucial importance. Most of the studies conducted in Nigeria focus on the southern regions of the country or on major urban areas like the Lagos, Abuja and Enugu context, which are marked by significant differences in socioeconomic, infrastructural and institutional endowments from the North-West Nigeria (Sani & Umar, 2023). This geographical imbalance in the research literature has resulted in an absence of contextually specific evidence base for designing context-specific, effective, and sustainable integration strategies for TEL in the region, leaving educational managers and policymakers in the region without the necessary evidence base to do so.

STATEMENT OF THE PROBLEM

Teaching and learning in public secondary schools in North-West Nigeria continues to be a paramount concern of both the teachers and policy makers. In contemporary teaching, Technology-Enhanced Learning (TEL) has emerged as a crucial enabler for enhancing the delivery of learning, student engagement, and interaction in the classroom. Though the government has been advocating for the integration of ICTs in Nigerian schools, it is not well documented how teachers in public secondary schools in the North-West Nigeria are taking and using TEL in their teaching. Although much of the region's education still uses traditional pedagogies, there is not enough empirical evidence to evaluate the impact of current regional education technology programs.

The evidence collected from schools in the region shows that many teachers experience difficulties with ICTs infrastructure, internet access, electricity supply as well as digital literacy skills, which interferes with the effective use of TELs in schools. Although teachers have their own smartphone or digital device, it seems that the use of these is not extended into the formal teaching space. Moreover, the majority of the research work on TEL in Nigeria had focused on southern regions and major cities, with little research work conducted in the North-West region of Nigeria. Thus, empirical information is scarce regarding the extent of TEL use, its impact on teaching effectiveness, the instruments being used, problems faced and strategies to enhance implementation in public secondary schools of North-West Nigeria. This study was thus undertaken to fill in this gap.

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RESEARCH QUESTIONS

The following research questions guided the study:

1. What is the level of adoption of Technology-Enhanced Learning among teachers in public secondary schools in North-West Nigeria?
2. To what extent does Technology-Enhanced Learning influence teaching effectiveness in public secondary schools in North-West Nigeria?
3. What types of Technology-Enhanced Learning tools and resources are utilized by teachers in public secondary schools in North-West Nigeria?

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4. What are the challenges affecting the adoption of Technology-Enhanced Learning among teachers in public secondary schools in North-West Nigeria?
5. What strategies can be adopted to improve the adoption of Technology-Enhanced Learning to enhance teaching effectiveness in public secondary schools in North-West Nigeria?

OBJECTIVES OF THE STUDY

The main objective of this study is to examine the adoption of Technology-Enhanced Learning and its influence on teaching effectiveness in public secondary schools in North-West Nigeria. The specific objectives are to:

1. Determine the level of adoption of Technology-Enhanced Learning among teachers in public secondary schools in North-West Nigeria;
2. Examine the extent to which Technology-Enhanced Learning influences teaching effectiveness in public secondary schools in North-West Nigeria;
3. Identify the types of Technology-Enhanced Learning tools and resources utilized by teachers in public secondary schools in North-West Nigeria;
4. Investigate the challenges affecting the adoption of Technology-Enhanced Learning among teachers in public secondary schools in North-West Nigeria; and
5. Propose strategies for improving the adoption of Technology-Enhanced Learning to enhance teaching effectiveness in public secondary schools in North-West Nigeria.

REVIEW OF RELATED LITERATURE

Concept and Scope of Technology-Enhanced Learning

Technology-Enhanced Learning is a multidimensional construct that encompasses the deliberate use of any digital technology to support or transform the process of learning and teaching. Unlike the narrower concept of e-learning which typically denotes online-only or predominantly digital instructional delivery TEL is a broader umbrella concept that includes any application of technology, whether digital hardware, software, connectivity, or multimedia content, that meaningfully augments instructional quality and learning experience (Ally & Samaka, 2023). At its richest, TEL involves the seamless integration of digital tools with sound pedagogical practice to create learning environments that are more engaging, personalised, interactive, and effective than what is achievable through conventional, technology-free instruction.

Scholars have categorised TEL tools and resources along several dimensions. By modality, TEL resources include audio-visual materials (educational videos, podcasts, and audio recordings), text-based digital resources (e-books, digital library databases, and online journals), interactive applications (simulations, game-based learning tools, and virtual laboratories), communication platforms (email, instant messaging, and video conferencing), and Learning Management Systems (LMS) such as Moodle, Google Classroom, and Edmodo (Okafor & Nwachukwu, 2023). By hardware, TEL resources encompass desktop computers, laptops, tablets, smartphones, interactive whiteboards, digital projectors, and other devices that serve as access points for digital content and communication. In the context of North-West Nigerian public secondary schools, the most accessible category of TEL hardware is the smartphone, whose penetration among teachers significantly outpaces that of other digital devices (Garba & Yakubu, 2023).

The relationship between TEL adoption and teaching quality is mediated by numerous contextual factors, including teacher digital literacy, the availability and reliability of supporting infrastructure, institutional culture, leadership support, and the alignment between technology use and curriculum objectives. Research across diverse educational settings has consistently

demonstrated that TEL adoption, when supported by adequate training and infrastructure, can improve the breadth and depth of instructional resources available to teachers, enhance lesson planning quality, increase student engagement and motivation, and support more timely and data-driven assessment practices (Bello & Abdullahi, 2022; Ibrahim & Suleiman, 2024).

Teaching Effectiveness in the Digital Age

Teaching effectiveness is a multifaceted construct encompassing a teacher's ability to plan, deliver, manage, assess, and reflect on instruction in ways that produce meaningful, measurable, and sustainable improvements in student learning. Traditional frameworks of teaching effectiveness have emphasised subject matter knowledge, pedagogical skill, classroom management, and professional disposition as core dimensions of instructional quality (Yusuf & Mohammed, 2022). In the twenty-first century, however, the integration of digital technology has increasingly been recognised as an additional and essential dimension of teaching effectiveness, reflecting the growing expectation that professionally competent teachers possess not only content and pedagogical knowledge but also the technological knowledge and skills needed to leverage digital tools in service of learning goals (Ibrahim & Suleiman, 2024).

Okafor and Nwachukwu (2023) found that teachers in Nigerian secondary schools who actively integrated digital tools into their instruction demonstrated higher levels of instructional innovation, more frequent use of formative assessment strategies, and greater capacity for personalising instruction to meet diverse learner needs compared to their non-adopting counterparts. These differences were reflected in students' reported levels of engagement and in their performance on assessment tasks. Bello and Abdullahi (2022) similarly documented significant improvements in student engagement and academic performance in secondary schools where teachers consistently used projectors and educational software in lesson delivery. These findings underscore the practical significance of TEL adoption for teaching quality in the Nigerian context.

Challenges of TEL Adoption in Nigerian Secondary Schools

The challenges confronting TEL adoption in Nigerian public secondary schools are well-documented and multidimensional. At the infrastructural level, the most frequently cited barriers include inadequate and unreliable electricity supply, poor internet connectivity, insufficient ICT hardware and software, and the absence of dedicated ICT laboratories or digital resource centres (Garba & Yakubu, 2023; Aliyu & Garba, 2023). These structural deficits are particularly pronounced in North-West Nigeria, where they are compounded by factors such as chronic underfunding of public education, security challenges that disrupt schooling and deter infrastructure investment, and geographic remoteness that limits connectivity options (UNICEF, 2022).

At the capacity level, insufficient teacher training in digital literacy and TEL pedagogy has been identified as a critical constraint. Many public secondary school teachers in the North-West zone entered the profession at a time when ICT integration was not a component of teacher education curricula, and they have since had limited access to structured, sustained, and practically-oriented professional development in educational technology (Aliyu & Garba, 2023). The Technology Acceptance Model (TAM) provides a useful framework for understanding how teachers' perceptions of TEL's usefulness and ease of use perceptions that are significantly shaped by training and exposure influence their adoption decisions (Sulaiman & Hashim, 2023).

Attitudinal barriers, including resistance to change among experienced teachers, anxiety about technological competence, and scepticism about the educational value of digital tools, further compound structural and capacity-related challenges (Kwaghe & Okunola, 2023). Gender disparities in technology access and use have also been documented in Northern Nigerian contexts, with female teachers facing additional barriers related to device ownership limitations and socio-cultural constraints on technology engagement (Garba & Yakubu, 2023). These intersecting challenges call for multi-level, context-sensitive intervention strategies that address structural, capacity, attitudinal, and equity dimensions simultaneously.

RESEARCH METHODOLOGY

Research Design

The study adopted a descriptive survey research design, which is appropriate because it enables the systematic collection of data from a large and geographically dispersed population in order to describe existing conditions, practices, perceptions, and relationships without manipulating the study variables (Adeyemi & Yusuf, 2023). Descriptive survey design is widely employed in educational research to examine the perceptions, adoption levels, and effectiveness of instructional innovations such as TEL, and has been identified as suitable for studies involving teachers across multiple locations where generalisability of findings is a priority.

Population of the Study

The population of the study comprised all teachers in public secondary schools in the seven states of the North-West geopolitical zone of Nigeria, with a total population of 60,410 teachers. Teachers were selected as the study's population because they are the direct implementers of TEL tools and pedagogical strategies at the classroom level and thus the most consequential stakeholders for understanding TEL adoption and its influence on teaching effectiveness. The population encompassed teachers in urban and rural schools, boys', girls', and co-educational institutions across all seven states, ensuring diversity and representativeness (Abdullahi & Musa, 2023). Table 1 presents the distribution of the population by state.

Table 1: Population Distribution of Teachers in Public Secondary Schools, North-West Nigeria

S/N	State	Selected Public Secondary Schools	Category	Teachers
1	Kaduna	Govt. SS Ungwan Rimi; Govt. Girls SS Kawo; Govt. Day SS Zaria	Public SS Teachers	11,250
2	Kano	Govt. College Kano; Govt. SS Bichi; Govt. Girls SS Dala	Public SS Teachers	14,560
3	Katsina	Govt. SS Katsina; Govt. Day SS Funtua; Govt. Girls SS Daura	Public SS Teachers	9,120
4	Jigawa	Govt. College Birnin Kudu; Govt. SS Dutse; Govt. Girls SS Hadejia	Public SS Teachers	6,600
5	Kebbi	Govt. SS Birnin Kebbi; Govt. Day SS Argungu; Govt. Girls SS Yauri	Public SS Teachers	5,980
6	Sokoto	Govt. SS Sokoto; Govt. Day SS Illela; Govt. Girls SS Wamakko	Public SS Teachers	6,960
7	Zamfara	Govt. SS Gusau; Govt. Day SS Sankalawa; Govt. Girls SS Kaura Namoda	Public SS Teachers	5,940
	Total			**60,410**

Source: State Ministries of Education, North-West Zone (2023).

Key: SS = Secondary School

Sample Size and Sampling Technique

Given the large size of the target population, a representative sample was determined using Yamane's (1967) formula for finite population sampling at a 5% margin of error. The calculation yielded a minimum sample of 397 teachers. To improve precision and account for potential non-response, the sample was augmented to 630, distributed proportionately across the seven states using proportionate stratified random sampling. This technique ensures that the representation of each state in the sample is proportional to its share of the total population, thereby enhancing the representativeness and external validity of the findings (Adeyemi & Yusuf, 2023). Table 2 presents the sample size distribution by state.

Table 2: Sample Size Distribution by State

S/N	State	Population	Sample (n)	% of Total Stratum
1	Kaduna State	11,250	117	18.6%
2	Kano State	14,560	152	24.1%
3	Katsina State	9,120	95	15.1%
4	Jigawa State	6,600	69	11.0%
5	Kebbi State	5,980	62	9.8%
6	Sokoto State	6,960	73	11.6%
7	Zamfara State	5,940	62	9.8%
	Total	**60,410**	**630**	**100%**

Note: Sample sizes calculated using Yamane's (1967) formula; $n = N / (1 + N(e)^2)$, where N = population, e = 0.05.

Of the 630 questionnaires distributed, 589 were returned and found to be validly completed, yielding a response rate of 93.5%. This rate is considered excellent for survey research and is sufficient to support the validity and generalisability of the findings (Adeyemi & Yusuf, 2023). The final sample comprised 62.3% male and 37.7% female respondents, with 34.1% having between five and ten years of teaching experience and 48.2% holding a Nigeria Certificate in Education (NCE) as their highest qualification.

Research Instrument

The primary instrument for data collection was a structured questionnaire containing 50 items divided into five sections based on the research objectives: TEL adoption level, influence of TEL on teaching effectiveness, TEL tools utilized, challenges affecting TEL adoption, and strategies for improving TEL adoption. Sections 1, 2, 3, 4, and 5 were measured using a four-point Likert scale ranging from Strongly Agree (4) to Strongly Disagree (1), with 2.50 as the decision mean. The instrument was validated by three experts in Library and Information Science and Educational Technology. A pilot test involving 30 teachers produced a Cronbach's Alpha reliability coefficient of 0.84, indicating high reliability. Data collected were analyzed using SPSS version 26 through descriptive statistics such as frequency, percentage, mean, and standard deviation.

RESULTS AND DISCUSSION

Level of TEL Adoption Among Teachers

The first objective of the study was to determine the level of TEL adoption among teachers in public secondary schools in North-West Nigeria. The ten items measuring TEL adoption were analysed and the results presented in Table 3.

Table 3: Level of TEL Adoption Among Teachers in Public Secondary Schools, North-West Nigeria

S/N	Level of TEL Adoption Among Teachers	SA	A	D	SD	Mean	StD
1	Teachers use digital communication platforms (WhatsApp/email) for instructional communication with students	240	210	85	54	3.0798	2.7051
2	Teachers are familiar with and have used at least one online learning platform (e.g., Google Classroom)	215	195	102	77	2.9304	2.5909
3	Teachers encourage students to use digital tools for learning and research tasks	205	190	110	84	2.8761	2.5467
4	Teachers use presentation software (e.g., PowerPoint) to deliver lessons in the classroom	198	187	116	88	2.8404	2.5165
5	Teachers regularly use digital devices (computer, tablet, smartphone) to prepare lessons	194	186	118	91	2.8200	2.4996
6	Teachers use digital video or audio resources to support lesson delivery	180	182	130	97	2.7555	2.4419
7	Teachers access the internet to find educational resources and teaching materials	176	180	134	99	2.7351	2.4237
8	Teachers use educational applications or software in instructional activities	168	171	142	108	2.6774	2.3763
9	Teachers have received formal in-service training on technology use in teaching	145	160	158	126	2.5501	2.2629
10	Schools provide sufficient digital devices and ICT infrastructure for teaching	132	149	166	142	2.4601	2.1842
	Cumulative Mean					**2.7725**	**2.4548**

Key: Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)
Source: Field Survey, 2026 Decision Mean = 2.50

Table 3 reveals the level of Technology-Enhanced Learning (TEL) adoption among teachers in public secondary schools in North-West Nigeria. The highest mean score of 3.0798 and standard deviation of 2.7051 indicates that teachers mostly use digital communication platforms such as WhatsApp and email for instructional communication with students, with 240 respondents strongly agreeing, 210 agreeing, 85 disagreeing, and 54 strongly disagreeing. Similarly, familiarity with online learning platforms such as Google Classroom recorded a mean score of 2.9304 and standard deviation of 2.5909, while encouraging students to use digital tools for learning and research tasks recorded a mean score of 2.8761 and standard deviation of 2.5467, indicating substantial adoption of these TEL practices among respondents. Furthermore, use of presentation software, digital devices for lesson preparation, digital video or audio resources, and internet access for educational materials all recorded mean scores above the 2.50 benchmark, suggesting moderate adoption of instructional technologies by teachers. In the same vein, educational applications or software and formal in-service training on technology use in teaching recorded mean scores of 2.6774 and 2.5501 respectively, indicating that respondents generally agree that these practices are moderately available. However, provision of sufficient digital devices and ICT infrastructure by schools recorded the lowest mean score of 2.4601 and standard deviation of 2.1842, suggesting inadequacy of institutional infrastructure support for TEL implementation. The cumulative mean score of 2.7725 and standard deviation of 2.4548, which is above the 2.50 decision benchmark, implies that the level of TEL adoption among teachers in public secondary schools in North-West Nigeria is moderately high, although institutional infrastructure remains inadequate.

Influence of TEL on Teaching Effectiveness

The second objective was to examine the extent to which TEL adoption influences teaching effectiveness. The analysis focused on teachers who had reported any level of TEL adoption and asked them to rate the influence of digital tool use on ten dimensions of teaching effectiveness. Table 4 presents the results.

Table 4: Influence of TEL on Teaching Effectiveness Among Teachers

S/N	Influence of TEL on Teaching Effectiveness	SA	A	D	SD	Mean	StD
1	TEL improves student engagement and active participation in lessons	268	220	63	38	3.2190	2.8134
2	TEL enhances quality of lesson delivery and instructional presentation	251	215	76	47	3.1375	2.7499
3	TEL improves lesson planning and preparation quality	236	206	88	59	3.0509	2.6843
4	TEL enhances assessment practices and feedback delivery	228	201	94	66	3.0034	2.6479
5	TEL supports differentiation and responsiveness to learner needs	220	196	99	74	2.9541	2.6105
6	TEL improves professional confidence and instructional innovation	214	194	102	79	2.9219	2.5851
7	TEL enhances timeliness and relevance of feedback to students	210	190	105	84	2.8930	2.5633
8	TEL improves student academic performance and learning outcomes	205	187	108	89	2.8625	2.5393
9	TEL improves classroom management efficiency	201	184	111	93	2.8370	2.5192
10	TEL enhances overall professional teaching effectiveness	198	180	114	97	2.8132	2.5009
	Cumulative Mean					**2.9693**	**2.6214**

Key: Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)
Source: Field Survey, 2026 Decision Mean = 2.50

Table 4 reveals the influence of Technology-Enhanced Learning (TEL) on teaching effectiveness among teachers in public secondary schools in North-West Nigeria. The highest mean score of 3.2190 and standard deviation of 2.8134 indicates that TEL most strongly improves student engagement and active participation in lessons, with 268 respondents strongly agreeing, 220 agreeing, 63 disagreeing, and 38 strongly disagreeing. Similarly, enhancement of lesson delivery and instructional presentation recorded a mean score of 3.1375 and standard deviation of 2.7499, while improvement in lesson planning and preparation quality recorded a mean score of 3.0509 and standard deviation of 2.6843, indicating that respondents strongly perceive TEL as improving instructional quality and classroom delivery. Furthermore, assessment practices and feedback delivery, responsiveness to learner needs, professional confidence, timeliness of feedback, student academic performance, and classroom management efficiency all recorded mean scores above the 2.50 decision benchmark, suggesting that respondents generally agree that TEL positively influences multiple dimensions of teaching effectiveness. Although overall professional teaching effectiveness recorded the lowest mean score of 2.8132 and standard deviation of 2.5009, responses still indicate

positive perception among respondents. The cumulative mean score of 2.9693 and standard deviation of 2.6214, which is above the 2.50 benchmark, implies that TEL adoption has a substantial positive influence on teaching effectiveness among teachers in public secondary schools in North-West Nigeria.

Types of TEL Tools and Resources Utilised

The third objective was to identify the types of TEL tools and resources utilised by teachers in public secondary schools in North-West Nigeria.

Table 5: Types of TEL Tools and Resources Utilised by Teachers

S/N	TEL Tools and Resources Utilised	SA	A	D	SD	Mean	StD
1	Mobile phones are utilized for educational purposes	320	190	45	34	3.3514	2.9339
2	WhatsApp is utilized for instructional communication	298	185	60	46	3.2479	2.8565
3	YouTube and other video-based resources are used for teaching	210	175	112	92	2.8539	2.5379
4	Microsoft Office is utilized for lesson preparation	205	170	118	96	2.8217	2.5118
5	Projectors are used for classroom presentations	190	165	126	108	2.7419	2.4453
6	Desktop or laptop computers are utilized for instructional activities	184	160	132	113	2.7046	2.4139
7	Educational applications and software are utilized for teaching	170	158	140	121	2.6401	2.3555
8	Digital libraries and open educational resources are utilized	162	154	145	128	2.5942	2.3155
9	Online learning platforms such as Google Classroom are utilized	150	148	152	139	2.5246	2.2538
10	Bluetooth and offline content-sharing mechanisms are utilized	138	145	160	146	2.4669	2.1982
	Cumulative Mean					**2.7947**	**2.4822**

Key: Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)
Source: Field Survey, 2026 Decision Mean = 2.50

Table 5 presents the types of Technology-Enhanced Learning (TEL) tools and resources utilized by teachers in public secondary schools in North-West Nigeria. The highest mean score of 3.3514 and standard deviation of 2.9339 indicates that mobile phones are the most widely utilized TEL tools for educational purposes, with 320 respondents strongly agreeing, 190 agreeing, 45 disagreeing, and 34 strongly disagreeing. Similarly, WhatsApp utilization for instructional communication recorded a mean score of 3.2479 and standard deviation of 2.8565, indicating strong adoption among respondents. Furthermore, YouTube and video-based resources, Microsoft Office applications, projectors, desktop or laptop computers, educational applications, digital libraries, and online learning platforms all recorded mean scores above the 2.50 decision benchmark, suggesting moderate utilization of these TEL tools and resources for instructional activities. However, Bluetooth and offline content-sharing mechanisms recorded the lowest mean score of 2.4669 and standard deviation of 2.1982, indicating comparatively lower utilization among respondents. The cumulative mean score of 2.7947 and standard deviation of 2.4822, which is above the 2.50 benchmark, implies that teachers moderately utilize a variety of TEL tools and resources, with mobile phones and WhatsApp emerging as the dominant technologies for teaching and learning activities in public secondary schools in North-West Nigeria.

Challenges Affecting TEL Adoption

The fourth objective was to investigate the challenges affecting TEL adoption among teachers in public secondary schools in North-West Nigeria. All ten challenge items recorded mean scores above the 2.50 criterion, confirming that all identified challenges are significant barriers to TEL adoption in the region. Table 5 presents the results.

Table 6: Challenges Affecting TEL Adoption Among Teachers in Public Secondary Schools, North-West Nigeria

S/N	Challenges Affecting TEL Adoption	SA	A	D	SD	Mean	StD
1	Inadequate and unreliable electricity supply limits the use of digital tools in schools	340	200	30	19	3.4618	3.0110
2	Poor or absent internet connectivity prevents access to online educational resources	330	198	38	23	3.4177	2.9781
3	Schools lack sufficient ICT infrastructure such as computers and projectors	320	195	45	29	3.3684	2.9426
4	Insufficient government funding affects TEL tool procurement	310	192	52	35	3.3192	2.9066
5	Lack of formal teacher training affects TEL adoption	305	190	56	38	3.2937	2.8878
6	High cost of data and internet subscription affects TEL utilization	286	188	67	48	3.2088	2.8230

7	Absence of clear school-level policy on technology use affects TEL implementation	278	184	72	55	3.1629	2.7897
8	Limited personal digital literacy skills affect effective TEL use	270	180	76	63	3.1155	2.7555
9	Security concerns discourage teachers from bringing digital devices to school	240	170	98	81	2.9660	2.6371
10	Cultural and social factors limit students' access to digital devices	225	165	104	95	2.8829	2.5725
	Cumulative Mean					**3.2197**	**2.8304**

Key: Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)
Source: Field Survey, 2026 Decision Mean = 2.50

Table 6 reveals the challenges affecting Technology-Enhanced Learning (TEL) adoption among teachers in public secondary schools in North-West Nigeria. The highest mean score of 3.4618 and standard deviation of 3.0110 indicates that inadequate and unreliable electricity supply is the most significant challenge affecting TEL adoption, with 340 respondents strongly agreeing, 200 agreeing, 30 disagreeing, and 19 strongly disagreeing. Similarly, poor or absent internet connectivity and inadequate ICT infrastructure recorded mean scores of 3.4177 and 3.3684 respectively, indicating strong agreement that infrastructural deficiencies significantly hinder effective TEL implementation in schools. Furthermore, insufficient government funding, lack of formal teacher training, high cost of internet subscription, and absence of school-level technology policies all recorded high mean scores above the 2.50 benchmark, suggesting that financial, technical, and institutional constraints are major barriers to TEL adoption. In the same vein, limited personal digital literacy skills, security concerns, and cultural or social factors affecting students' access to digital devices also recorded mean scores above the benchmark, indicating that respondents generally perceive these factors as additional challenges affecting TEL implementation. The cumulative mean score of 3.2197 and standard deviation of 2.8304, which is above the 2.50 decision benchmark, implies that teachers strongly agree that infrastructural, financial, technical, and socio-cultural barriers significantly affect effective TEL adoption in public secondary schools in North-West Nigeria

Strategies for Improving TEL Adoption

The fifth objective was to propose strategies for improving TEL adoption to enhance teaching effectiveness in public secondary schools in North-West Nigeria. All ten strategy items recorded mean scores above the 2.50 criterion, indicating broad respondent endorsement of all proposed strategies. Table 6 presents the results.

Table 7: Strategies for Improving TEL Adoption in Public Secondary Schools, North-West Nigeria

S/N	Strategies for Improving TEL Adoption	SA	A	D	SD	Mean	StD
1	Reliable electricity supply or solar power systems should be provided in schools	355	198	22	14	3.5178	3.0536
2	Government should provide ICT devices such as computers and tablets to teachers and students	348	195	28	18	3.4822	3.0284
3	Teachers should receive regular in-service training on digital literacy and TEL pedagogy	340	192	34	23	3.4414	2.9997
4	Internet connectivity should be improved through educational broadband access	332	190	40	27	3.4041	2.9724
5	National TEL policy frameworks should be developed for effective implementation	324	188	45	32	3.3650	2.9443
6	Schools should collaborate with NGOs and private organizations for TEL support	316	185	50	38	3.3226	2.9142
7	Locally relevant offline educational content should be developed	308	180	56	45	3.2750	2.8807
8	TEL competency should be included in teacher performance appraisal systems	300	176	60	53	3.2275	2.8476
9	School-level technology committees should be established to coordinate TEL activities	286	172	68	63	3.1562	2.7946
10	Comprehensive TEL pedagogy should be integrated into pre-service teacher education	280	168	72	69	3.1188	2.7678
	Cumulative Mean					**3.3311**	**2.9203**

Key: Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)
Source: Field Survey, 2026 Decision Mean = 2.50

Table 7 presents the strategies for improving Technology-Enhanced Learning (TEL) adoption in public secondary schools in North-West Nigeria. The highest mean score of 3.5178 and standard deviation of 3.0536 indicates that respondents strongly

agree that reliable electricity supply or solar power systems should be provided in schools, with 355 respondents strongly agreeing, 198 agreeing, 22 disagreeing, and 14 strongly disagreeing. Similarly, government provision of ICT devices such as computers and tablets and regular in-service training on digital literacy and TEL pedagogy recorded mean scores of 3.4822 and 3.4414 respectively, indicating strong support for infrastructural development and teacher capacity building. Furthermore, improved internet connectivity, development of national TEL policy frameworks, collaboration with NGOs and private organizations, and development of locally relevant offline educational content all recorded high mean scores above the decision benchmark, suggesting that respondents perceive these strategies as essential for effective TEL implementation. In the same vein, inclusion of TEL competency in teacher appraisal systems, establishment of school-level technology committees, and integration of TEL pedagogy into pre-service teacher education also recorded mean scores above 2.50, indicating broad agreement among respondents. The cumulative mean score of 3.3311 and standard deviation of 2.9203, which is above the 2.50 benchmark, implies that respondents strongly endorse infrastructural, policy, training, and institutional strategies for improving TEL adoption and enhancing teaching effectiveness in public secondary schools in North-West Nigeria.

DISCUSSION OF FINDINGS

This shows that Technology-Enhanced Learning (TEL) adoption among teachers in public secondary schools in North-West Nigeria is moderate, with stronger reliance on accessible tools such as mobile phones, WhatsApp, and other digital communication platforms for instructional purposes. The interpretation of the tables indicates that while teachers are increasingly integrating technology into teaching activities, its use is more prominent in communication and basic instructional support than in full pedagogical transformation. TEL was also found to positively influence teaching effectiveness across multiple dimensions, particularly in enhancing student engagement, improving lesson delivery, supporting lesson planning, strengthening assessment practices, and improving classroom interaction. This suggests that even limited integration of digital tools contributes meaningfully to instructional quality. These findings align with Ohanu et al. (2024), who reported that digital learning technologies significantly enhance teaching effectiveness in Nigerian educational settings, and Bepeh et al. (2023), who found a strong positive relationship between technology use and instructional performance among educators. The dominance of mobile-based tools supports Krochinak et al. (2023), who emphasized that mobile technologies remain the most accessible and widely used digital learning tools in resource-constrained environments.

However, the study also revealed that TEL adoption is constrained by inadequate electricity supply, poor internet connectivity, insufficient ICT infrastructure, lack of training, and limited institutional support. These barriers reflect findings by Mohebi et al. (2023), who identified infrastructure and capacity deficits as major obstacles to digital learning implementation. Furthermore, strong agreement on strategies such as improved infrastructure, teacher training, and policy development aligns with Ojetunde and Ramnarain (2023), who stressed that effective TEL implementation depends on coordinated investment in infrastructure, capacity building, and institutional frameworks. Moreover, the findings indicate that TEL has strong potential to improve teaching effectiveness, but its impact is limited by systemic challenges requiring urgent policy and infrastructural intervention.

CONCLUSION

This study generated substantial empirical evidence on the adoption of Technology-Enhanced Learning (TEL) and its influence on teaching effectiveness in public secondary schools in North-West Nigeria. The interpretations of the tables revealed that teachers moderately adopt TEL practices, as indicated by the cumulative mean score above the 2.50 benchmark, with digital communication platforms such as WhatsApp and email emerging as the most commonly utilized technologies for instructional communication. The findings further showed that TEL positively influences teaching effectiveness across several instructional dimensions, particularly in improving student engagement, lesson delivery, lesson planning, assessment practices, and classroom management, indicating that respondents generally perceive digital technologies as beneficial for enhancing

instructional quality. In addition, the study established that mobile phones and WhatsApp constitute the dominant TEL tools and resources utilized by teachers, while technologies such as online learning platforms, projectors, educational software, and digital libraries are moderately utilized due to infrastructural limitations. The study also identified major barriers affecting TEL adoption, including inadequate electricity supply, poor internet connectivity, insufficient ICT infrastructure, inadequate funding, lack of teacher training, high internet subscription costs, and absence of institutional technology policies, all of which recorded mean scores above the decision benchmark, suggesting that respondents strongly perceive these challenges as significant impediments to effective TEL implementation. Furthermore, the findings revealed strong respondent support for strategies aimed at improving TEL adoption, particularly the provision of reliable electricity or solar power systems, government provision of ICT devices, regular teacher training, improved internet connectivity, development of TEL policy frameworks, collaboration with NGOs and private organizations, and integration of TEL pedagogy into teacher education programmes. In addition, the cumulative findings indicate that although teachers in North-West Nigeria recognize the importance and benefits of TEL for improving teaching effectiveness, effective implementation remains constrained by infrastructural, financial, technical, and institutional challenges that require coordinated policy, capacity-building, and technological interventions for sustainable educational transformation.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are made:

1. Federal and state governments should prioritize the provision of reliable electricity supply, including solar power systems and alternative renewable energy sources, in public secondary schools across North-West Nigeria to ensure sustainable Technology-Enhanced Learning (TEL) implementation.
2. Government and relevant educational stakeholders should provide adequate ICT infrastructure and digital devices such as laptops, tablets, projectors, internet facilities, and other instructional technologies to teachers and students, particularly in rural and underserved schools.
3. State Ministries of Education and school administrators should develop and implement comprehensive TEL policies, establish school technology committees, and create supportive institutional environments that encourage effective technology integration in teaching and learning.
4. Regular training programmes, workshops, seminars, and professional development activities on digital literacy and TEL pedagogy should be organized for teachers to improve their technological competence and instructional effectiveness.
5. Teachers should maximize the use of accessible technologies such as smartphones, WhatsApp, YouTube, educational applications, and online learning platforms, while also adopting offline and low-bandwidth technological solutions suitable for low-connectivity environments.
6. Educational stakeholders, including governments, NGOs, private organizations, and international development partners, should collaborate to provide funding, technical support, internet connectivity, and other resources necessary for effective TEL adoption in public secondary schools.
7. Researchers and teacher education institutions should conduct further studies and integrate comprehensive TEL pedagogy and digital literacy into pre-service and in-service teacher education programmes to strengthen future technology integration in Nigerian secondary schools.

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